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An Evaluation of MoninObukhov Similarity Theory within the Marine Atmospheric Surface Layer: The Prevalence of the Constant Stress Layer

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13.2: An Evaluation of Monin–Obukhov Similarity Theory within the Marine Atmospheric Surface Layer: The Prevalence of the Constant Stress Layer

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Monin-Obukhov Similarity Theory (MOST) forms the backbone for many studies of the atmospheric surface layer (ASL), whether over land or ocean, and is critical to predicting the electromagnetic (EM) propagation in the marine environment. Fundamentally, MOST extends the Richardson-Prandtl flux-gradient relationship to the general case of non-neutral conditions using dimensionless, empirical functions for momentum, temperature, moisture, and turbulent energy dissipation. These empirical functions provide a means to represent surface fluxes from mean quantities such as those from gridded numerical simulations. A critical component to the underlying basis for MOST, and the flux-gradient relationship, is the constant flux layer assumption. In the neutral conditions, the absence of stress divergence implies that only one relevant turbulent velocity scale is needed to close the surface flux problem (e.g., the friction velocity). However, in the marine environment, flux profile measurements are rarely collected and the overwhelming majority of data sets cannot confirm the presence of this critical assumption over typical averaging windows. Using a complete (momentum and total heat), high-resolution flux profile (ranging 2-16 m above the surface) collected during the CASPER-West field campaign, we have conducted a study that systematically evaluates the prevalence of the constant flux layer model over the marine ASL (MASL). These measurements were taken from the Research Platform (R/P) *FLIP*, which is an ideal ocean-going platform for making near-surface measurements free from the contaminations endemic to typical ship-based measurements. We utilize a novel approach to empirically test each observed profile of momentum, sensible, and latent heat flux against a sufficiently constant profile. This enabled us to analyze the dependence of whether or not an individual profile was "constant" against the mean environmental state, e.g., wind speed, stability, and air-sea temperature difference. For the momentum flux, we found that only 33% of profiles could be considered non-divergent, which drops to 10% if only considering the profiles below 6 m. If only considering statistically stationary profiles (~20% of the total data set), we found that 43% of profiles were sufficient constant stress. Similar findings were observed for sensible heat flux, with a dramatic increase in the prevalence of non-divergence for the latent heat flux. An analysis into the environmental dependence of these general results will be presented. These results question the generally held assumption that the MASL is typically a constant stress layer; this holds significant implications for how surface fluxes are parameterized and/or derived over the ocean, as well as the widespread reliance on MOST to accurately describe the vertical structure of the MASL.

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